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TECHNICAL MEMORANDUM NO. 5-75

DSRV ALVIN WEIGHT REPORT, 1975

Arnold G. Sharp

October 1975

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Memo. 5-75
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WOODS HOLE OCEANOGRAPHIC INSTITUTION
Woods Hole, Massachusetts 02543

TECHNICAL MEMORANDUM 5-75

DSRV ALVIN WEIGHT REPORT, 1975

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Woods Hole Oceanographic Institution

Arnold G. Sharp

October 1975

Office of Naval Research Contract No.
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Abstract

Weight and stability information has been updated for the research submarine ALVIN for 1975. The report includes results of the computations programmed for the Institution's XDS Sigma-7 computer, observed values resulting from the tethered trim dive and inclining experiments, and miscellaneous stability calculations. Principal results are the weight, displacement, and longitudinal and vertical components of the BG and GM distances, for the complete submersible, and for various major sub-assemblies.

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I. Introduction

The following is a summary of the various weight and stability determinations made for the research deep-submersible ALVIN during 1975. Included are programmed computations done on the Institution's Sigma-7 computer (made by Xerox Data Systems), experimentally determined values obtained during the tethered trim dive and inclining experiments (performed at the W.H.O.I. dock), and miscellaneous hand calculations related to various aspects of stability.

Changes made to the vehicle during the 1974-75 overhaul period are reflected in this weight report. Principally, they are:

1. New battery boxes
2. New control center
3. New main ballast tank, upper afterbody
4. New syntactic foam, upper afterbody

A number of minor changes to ALVIN also are shown, some of which were made after the preliminary version of this report was issued (Ref. 1).

Compared to the old battery boxes, the new boxes weigh less in air, but also displace considerably less. The net result is that each box is about 100 pounds heavier in water. The new control center is nearly neutrally buoyant, weighing

37 pounds in water. It is located on the port side in a space originally occupied by a rubber bag (part of the old variable ballast system) and more recently, by a syntactic foam package. New syntactic foam (to replace older foam suspected of being water-absorbent), and a new auxilliary main ballast tank, are both located in the upper part of the afterbody. They were installed this year with the hope of improving the freeboard and stability of the vehicle on the surface.

The weight and stability calculations are in the usual form and they are described in detail in the following section of this report.

II. Weight and Stability Computations

Explanation of Procedure In computing the weight and stability of ALVIN, two separate force systems were considered. The weights, acting downward, were summed to find the total weight, which acts at the center of gravity G. Similarly, the buoyancy forces, which act upward, were summed to find the total buoyant force or displacement, which acts at the center of buoyancy B. The locations of G and B were determined by summing the moments of weights and displacements with respect to the forward perpendicular and the base plane. Points G and B are assumed to lie in a vertical plane which passes through the longitudinal centerline of the submarine.

For the computer run, data were obtained for the separate components (or packages) and a data card was punched for each. The items were broken down into subgroups as follows (refer to computer printout sheets):

1. Sphere only (pressure hull plus contents)
2. Other forebody
3. Afterbody
4. Variable load
5. Entire vehicle

Figure 1. Longitudinal Section of ALVIN Showing Sample of Data Used in Computations

Figure 2. Longitudinal Section of ALVIN Showing Components of BG Distance

Figure 3. Transverse Section of ALVIN Showing Locations of Points K, G, B, B' and M

6. Released forebody

7. Emergency conditions

At the end of each subgroup the weight, displacement and moment summations were made, and the locations of G and B were determined. At the end of Section 4 (variable load) cumulative summations were made which yielded G and B values for the entire submarine in what is called the "normal submerged" condition. In this condition the main ballast tanks are flooded, the variable ballast tanks are two-thirds flooded, and the trim mercury is divided 50 percent forward and 50 percent aft.

Definition of Symbols The following symbols which appear on the computer printout sheets are defined here for convenience.

W - weight of item in air, lbs.

X - distance of center of gravity of item from forward perpendicular, feet (positive x means aft of F.P.; see Figure 1.)

Y - distance of center of gravity of item above base plane, feet (see Figure 1.)

MX - product of W times X, foot-lbs.

MY - product of W times Y, foot-lbs.

D - displacement of item, lbs. of seawater

XP - distance of center of buoyancy of item from forward perpendicular, feet (positive XP means aft of F.P.)

YP - distance of center of buoyancy of item above base plane, feet

MXP - product of D times XP, foot-lbs.

MYP - product of D times YP, foot-lbs.

BG longitudinal - distance between center of buoyancy B and center of gravity G, longitudinal component, feet (negative value indicates tendency for bow-up angle of trim; see Figure 2.)

BG vertical - distance between center of buoyancy B and center of gravity G, vertical component, feet (positive value indicates vertical stability of submerged vehicle; see Figure 2.)

The following additional terms and symbols appear in various places in this report:

Forward Perpendicular - vertical plane passing through foremost edge of front window cone of ALVIN (see Figure 1.)

Base Plane - horizontal plane passing through
bottom of skids of ALVIN (see Figure 1.)

B' - new position of center of buoyancy B.

Lateral shift occurs due to change of
underwater form when vehicle is inclined
on the surface (see Figure 3.)

Metacenter M - point found by extending line of
action of vertical buoyancy force through
B' to intersect with original vertical
centerline of vehicle inclined on the sur-
face (see Figure 3.)

GM - vertical distance from center of gravity G
to metacenter M (M above G indicates positive
stability of surfaced vehicle (see Figure 3.)

Outline of Programmed Computations

1. Total weight = summation W
2. Total displacement = summation D
3. Distance to center of gravity, longitudinal
$$XW = (\text{summation } MX) / (\text{summation } W)$$
4. Distance to center of gravity, vertical
$$YW = (\text{summation } MY) / (\text{summation } W)$$
5. Distance to center of buoyancy, longitudinal
$$XPD = (\text{summation } MXP) / (\text{summation } D)$$

6. Distance to center of buoyancy, vertical

$$YPD = (\text{summation MYP}) / (\text{summation D})$$

7. BG longitudinal = XPD - XW

8. BG vertical = YPD - YW

ALVIN WEIGHT AND STABILITY COMPUTATIONS
SPHERE ONLY

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MP
P HULL PINUS INSERTS	5081.54	4.97	4.89	25255.25	24848.73	10604.08	4.50	4.75	47718.36	50369.38
HULL INSERT FWC	383.78	1.14	4.75	437.51	1822.95	14.77	1.14	4.75	16.84	70.16
HULL INSERT BBT	386.28	3.72	1.42	1436.96	548.52	14.77	3.72	1.42	54.94	20.97
HULL INSERT PORT	387.29	2.39	3.46	925.62	1340.02	14.77	2.39	3.46	35.30	51.10
HULL INSERT STBD	385.54	2.39	3.46	921.44	1333.97	14.77	2.39	3.46	35.30	51.10
HATCH INSERT	261.53	4.50	8.11	1176.88	2121.01	9.28	4.50	8.11	41.76	75.26
WINDOW FWD	9.02	1.14	4.75	10.28	42.84	3.48	1.14	4.75	3.97	16.53
WINDOW BBT	9.02	3.72	1.44	33.55	12.99	3.48	3.72	1.44	12.95	5.01
WINDOWS P'S	18.04	2.35	3.46	43.12	62.42	6.96	2.35	3.46	16.63	24.08
WINDOW RET RING FWD	4.80	1.14	4.75	5.47	22.80	1.09	1.14	4.75	1.24	5.12
WINDOW RET RING BBT	4.80	3.72	1.30	17.86	6.24	1.09	3.72	1.30	1.05	1.42
WIND RET RINGS P'S	9.60	2.39	3.46	22.94	33.22	3.18	2.39	3.46	5.21	7.54
WIND RET RING P'S	48.50	4.50	1.33	218.25	64.50	5.45	4.50	1.21	24.70	6.64
SPHERE REL UPPER	199.34	4.50	8.11	897.03	1616.65	11.37	4.50	8.11	51.16	92.21
HATCH ARMS	4.57	4.21	8.28	19.24	37.84	1.05	4.21	8.28	4.42	8.69
HINGE SHAFT	3.25	4.00	8.28	13.00	26.91	1.75	4.00	8.28	3.00	6.21
INSIDE HANDLE	2.57	4.91	7.94	12.62	20.41	.00	.00	.00	.00	.00
OUTSIDE HANDLE	5.14	4.91	8.28	25.24	42.56	1.18	4.91	8.28	5.79	9.77
SPRING RETAINER	2.67	4.14	8.28	11.05	22.11	1.61	4.14	8.28	2.53	5.05
INT SWING CLAMP	1.52	4.60	7.94	6.99	12.07	.00	.00	.00	.00	.00
HINGE SPRINGS	12.05	4.00	8.28	48.20	99.77	1.94	4.00	8.28	5.80	12.01
HATCH WINDOW	2.02	4.50	8.19	9.09	16.54	.50	4.50	8.19	4.23	7.70
HATCH WIND RET RING	2.16	4.50	8.19	9.72	17.50	.50	4.50	8.19	4.23	4.05
HINGE BLOCKS	6.58	3.92	8.05	25.79	52.97	1.51	3.92	8.05	5.92	12.16
PENETRATORS (7) FWD	36.68	1.06	4.75	38.88	174.23	4.48	1.06	4.75	4.75	21.28
PENETRATORS (5) BBT	26.20	4.29	1.42	112.40	37.20	3.20	4.29	1.42	13.73	4.54
PENETRATORS (2) P	10.48	2.75	4.25	28.82	44.54	1.28	2.75	4.25	3.52	5.44
PENETRATORS (2) S	10.48	2.21	3.52	23.16	36.89	1.28	2.21	3.52	2.83	4.51
CABLE 24 COND 220 FT	85.80	2.50	2.70	214.50	231.66	4.24	2.50	2.70	105.60	114.05
BLANKING PLUGS (3) P	18.00	2.97	3.52	53.46	58.68	1.64	2.97	3.52	3.65	4.01
BLANKING PLUGS (4) S	24.00	3.04	3.52	72.96	84.48	1.64	3.04	3.52	4.99	5.77
LIFT PADS	10.20	4.50	8.17	45.90	83.33	2.35	4.50	8.17	10.57	19.20
CONN HALVES UPPER	52.50	4.50	1.09	236.25	57.22	5.25	4.50	1.09	23.63	57.22
MISC OUTSIDE	10.00	4.50	8.10	45.00	81.00	2.30	4.50	8.10	10.35	18.63
STRAZA MBD 100	30.00	3.13	5.53	93.90	165.90	.00	.00	.00	.00	.00
STRAZA MBD 200	32.00	4.04	5.53	129.28	190.72	.00	.00	.00	.00	.00
STRAZA MBD 300	40.00	4.37	6.67	174.80	266.80	.00	.00	.00	.00	.00
TAPE RECORDER	2.00	4.13	4.50	8.26	9.00	.00	.00	.00	.00	.00
02 ANALYZER	3.50	5.38	8.70	18.83	23.45	.00	.00	.00	.00	.00
02 BOTTLES (3)	105.00	6.71	3.79	704.55	397.95	.00	.00	.00	.00	.00

ALVIN WEIGHT AND STABILITY COMPUTATIONS
(CONTINUED)
SPHERE ONLY

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
LIBR CANISTERS (3)	24.00	6.29	5.00	150.96	120.00	.00	.00	.00	.00	.00
CABIN LIGHT	1.00	5.67	6.79	8.58	6.79	.00	.00	.00	.00	.00
EMERG BREATH APPAR 3	2.00	4.29	7.17	239.85	14.34	.00	.00	.00	.00	.00
VESTS (3)	45.00	5.33	5.88	31.98	264.60	.00	.00	.00	.00	.00
PILOTS CHAIR	6.00	5.33	5.88	26.81	35.28	.00	.00	.00	.00	.00
TRIP INDICATOR	9.31	2.88	2.88	.49	26.81	.00	.00	.00	.00	.00
CABIN LIGHTS,P,S(2)	.30	1.63	5.50	7.34	1.65	.00	.00	.00	.00	.00
MAP LIGHTS (4)	2.00	3.67	5.46	10.32	10.92	.00	.00	.00	.00	.00
FLASHLIGHTS	4.00	2.58	6.50	16.64	16.96	.00	.00	.00	.00	.00
MISC WIRING,HDR	8.00	4.58	4.75	45.50	47.50	.00	.00	.00	.00	.00
PERFORATOR LEADS	10.00	4.55	4.75	360.00	380.00	.00	.00	.00	.00	.00
ORIGINALS (3)	80.00	4.50	3.50	5.50	2.50	.00	.00	.00	.00	.00
CAMERAS	1.00	5.50	5.20	34.80	31.20	.00	.00	.00	.00	.00
TOOL KIT	6.00	5.50	2.40	22.00	9.60	.00	.00	.00	.00	.00
FLASHLIGHTS(6)	4.80	5.50	2.40	26.40	11.52	.00	.00	.00	.00	.00
SOUND PHONES(2)	5.00	4.30	7.00	25.80	42.00	.00	.00	.00	.00	.00
CUSHIONS	4.00	4.60	2.20	18.40	8.80	.00	.00	.00	.00	.00
RELEASE T-BAR	4.00	5.60	2.40	22.40	9.60	.00	.00	.00	.00	.00
RACK ASSEMBLIES	35.00	4.60	5.00	161.00	175.00	.00	.00	.00	.00	.00
EMERG WATER	5.00	6.00	2.80	30.00	14.00	.00	.00	.00	.00	.00
STED CISTR PANEL	42.00	2.90	6.25	121.80	262.50	.00	2.90	6.25	.00	.00
PORT WING PANEL	12.50	2.90	6.25	36.25	78.13	.00	.00	.00	.00	.00
RADIO	11.25	4.58	5.96	51.53	67.05	.00	.00	.00	.00	.00
U G C PANEL	31.00	4.29	6.75	132.25	203.25	.00	.00	.00	.00	.00
INSTR PANEL	17.00	1.75	6.25	29.75	106.25	.00	.00	.00	.00	.00
LOWER SHELVES(3)	17.50	2.90	5.50	36.25	68.75	.00	.00	.00	.00	.00
GYRO COMP	17.00	3.50	5.75	55.50	97.75	.00	.00	.00	.00	.00
POWER SUPPLY 6V	7.00	7.00	5.12	49.00	35.84	.00	.00	.00	.00	.00
INVERTER	27.00	7.67	3.75	20.00	176.58	.00	.00	3.75	.00	.00
POWER PANEL STBC	20.00	6.00	6.75	120.00	75.00	.00	6.00	.00	.00	.00
SHELF UPPER PORT	2.00	4.35	6.75	8.70	13.50	.00	.00	.00	.00	.00
SHELF OVER IND PANEL	3.50	4.75	6.60	15.22	23.63	.00	.00	.00	.00	.00
SHELF OVER LEAK DET.	1.50	1.70	7.04	2.55	9.90	.00	.00	.00	.00	.00
FATHOMETER SCOPE	2.00	2.88	6.29	5.76	14.08	.00	.00	.00	.00	.00
FATHOMETER XMTR (2)	7.00	3.83	6.29	26.81	44.03	.00	.00	.00	.00	.00
ALTIMETER	14.00	3.00	5.50	42.00	77.00	.00	.00	.00	.00	.00
O2 BOTTLE BRK (3)	5.00	6.71	3.79	11.25	35.00	.00	.00	.00	.00	.00
AIR REGEN UNIT	13.50	6.38	4.50	53.68	30.32	.00	.00	.00	.00	.00
				86.13	60.75	.00	.00	.00	.00	.00

ALVIN WEIGHT AND STABILITY COMPUTATIONS

PAGE 3

SPHERE ONLY (CONTINUED)

IDENTIFICATION	W	X	Y	HX	MY	D	XP	YP	MXP	MYP
SPHERE STEP HDWR	6.00	5.00	6.50	30.00	39.00	.00	.00	.00	.00	.00
BATTERY SHELF	3.00	5.63	7.33	16.89	21.99	.00	.00	.00	.00	.00
FIRE EXTING	10.50	5.57	4.50	58.48	47.25	.00	.00	.00	.00	.00
EMERG LIGHT BATT	5.00	6.50	4.50	32.50	22.50	.00	.00	.00	.00	.00
MISC SHEET METAL	5.00	4.50	4.50	22.50	22.50	.00	.00	.00	.00	.00
GYRO REFEATER	2.00	1.54	4.83	3.08	9.66	.00	.00	.00	.00	.00
FLARE BXX FLARES	6.00	5.38	5.87	32.28	35.22	.00	.00	.00	.00	.00
PILOTS CNTR BXX	7.00	2.00	7.00	14.00	49.00	.00	.00	.00	.00	.00
CLIMMETERS(2)	1.00	3.50	6.25	3.50	8.25	.00	.00	.00	.00	.00
FIRST AID KIT	1.00	6.20	2.79	6.20	2.79	.00	.00	.00	.00	.00
EMERG BATTERIES (3)	27.00	4.50	6.00	121.50	162.00	.00	.00	.00	.00	.00
ALNAV CLOCK	14.00	5.75	5.50	80.50	77.00	.00	.00	.00	.00	.00

SPHERE ONLY

SUMMARY	NO.	ITE'S	SUM W	S	MXW	S	MYW	SUM MX	SUM MY	SUM D	S	MXPD	S	MYPD	SUM MXP	SUM MYP
	92		8331.11		4.37		4.73	36372.21	39404.13	10780.82		4.47		4.74	48239.98	51065.38
BG LONGITUDINAL			.11					BG VERTICAL	.01							

OTHER FREEDOM

IDENTIFICATION	W	X	Y	PX	MY	D	XP	YP	MXP	MYP
SAIL,ETC	221.85	4.64	7.02	1029.38	1557.39	135.00	4.64	7.02	626.40	947.70
SPLASH GLARD	20.00	4.50	8.50	90.00	170.00	12.06	4.50	8.50	54.27	102.51
LITTON UP FBOY SYNT	19C4.50	4.64	7.00	8836.88	13331.50	2201.65	4.64	7.00	10215.66	15411.55
3M UPPER FOREBDCY	863.00	.38	7.00	327.94	6041.00	1434.65	.38	7.00	545.15	10042.20
LOWER SYNT RING	1052.00	4.42	3.43	4649.84	3608.36	1212.98	4.42	3.43	5361.37	4160.52
FRT WINCBM CBNE	35.00	.75	4.75	27.00	171.00	21.70	.75	4.75	16.27	103.07
MAIN BALLAST WATER	1346.00	4.50	6.00	6057.00	8076.00	1346.00	4.50	6.00	6057.00	8076.00
MAIN BALLAST TANKS	178.00	4.50	6.00	801.00	1068.00	107.50	4.50	6.00	483.75	645.00
VELOCIMETER	20.00	2.40	9.50	44.00	190.00	10.00	2.20	9.50	22.00	95.00
SAIL CONTROL BOX	30.00	7.00	12.00	102.00	360.00	20.00	3.40	12.00	68.00	242.00
SAIL BOX	107.00	7.00	9.00	749.00	963.00	72.00	7.00	9.00	504.00	648.00
FIBERGLASS CLAMP	9.00	2.39	3.46	9.56	13.84	2.22	2.39	3.46	5.31	7.68
SONAR UNIT	92.00	.50	8.00	46.00	736.00	30.00	.50	8.00	15.00	240.00
MAGNETIC COMPASS	9.07	7.00	10.13	63.49	91.88	8.33	7.00	10.13	58.31	84.38
EXTERIOR LIGHTS	24.00	2.50	5.40	60.00	129.60	8.00	2.50	5.40	20.00	43.20
CURRENT METER,ETC	18.08	3.50	13.20	63.28	238.66	4.00	3.50	13.20	14.00	52.80
PREC DEPTH XDCR	3.50	5.75	10.00	20.13	35.00	1.25	5.75	10.00	7.19	12.50
UGC XOUER	27.00	6.50	12.50	175.50	337.50	4.00	6.50	12.50	26.00	50.00
EGG CAMERAS (2)	104.00	.00	7.06	.00	734.24	30.00	.00	7.06	.00	211.80
STROBE FWR UNITS	48.00	7.50	7.25	360.00	348.00	32.00	7.50	7.25	240.00	232.00
FWD STROBE	54.00	.00	6.50	.00	351.00	16.00	.00	6.50	.00	104.00
8AR RADIO TRANS	1.70	7.50	12.00	12.75	20.40	.84	7.50	12.00	6.30	10.08
8AR FLASH LIGHT	1.70	7.50	12.00	12.75	20.40	.84	7.50	12.00	6.30	10.08
TV CAMERA	30.00	1.50	7.75	45.00	232.50	6.40	1.50	7.75	9.60	49.60
RESCUE SLING,SHCKLS	33.00	4.50	9.00	148.50	297.00	4.20	4.50	9.00	18.90	37.80

OTHER FOREBODY

SUMMARY	NO.	ITEMS.	SUM "	S	MXW	S	MYW	SUM MX	SUM MY	SUM D	S	MXPD	S	MYPD	SUM HXP	SUM MYP
	25		6229.40		3.8C		6.28	23641.00	39122.26	6721.57		3.62		6.19	24361.57	41617.48
BG LONGITUDINAL			0.17					BG VERTICAL	0.09							

ALVIN WEIGHT AND STABILITY COMPUTATIONS

AFTERBODY

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
FRAME	447.50	9.18	2.77	4108.05	1239.57	169.00	9.18	2.77	1551.42	468.13
ADDN T8 FRAME F	12.00	10.25	1.65	123.00	19.80	4.42	10.25	1.65	45.30	7.29
ADDN T8 FRAME S	8.50	10.25	1.65	87.13	14.02	3.13	10.25	1.65	32.08	5.18
LG BU8Y PKG AFT	.60	6.00	2.75	3.60	1.65	.22	6.00	2.75	1.32	.60
PINGER	2310.00	14.16	5.05	3270.90	11665.50	4082.56	14.16	5.05	5780.05	20616.93
SIDE BU8Y PKG (2)	87.00	14.00	6.75	1218.00	587.25	55.00	14.00	6.75	770.00	371.25
CTR BU8Y SPK UP CTR	433.00	10.40	6.75	4503.20	2922.75	692.00	10.40	6.75	7196.80	4671.00
M/B TANK UP AFTBDY	118.00	10.25	5.83	1289.50	687.94	210.71	10.25	5.83	2159.78	1228.44
M/B WATER UP CTR	224.00	10.25	6.33	2296.00	1417.92	525.93	10.25	6.33	5350.78	3329.14
V/B BU8Y PKG LWR P	55.50	10.25	6.83	568.88	379.06	34.81	10.25	6.83	356.80	237.75
V/B BU8Y PKG LWR P	300.00	10.25	6.83	3075.00	2049.00	309.00	10.25	6.83	3075.00	2049.00
V/B BU8Y PKG LWR P	253.00	10.18	6.20	2575.54	1568.60	449.78	10.18	6.20	4578.76	2788.64
V/B BU8Y PKG UP F	203.00	10.18	5.70	2117.44	1081.60	369.70	10.18	5.70	3763.55	1922.44
V/B BU8Y PKG UP S	433.45	10.18	6.20	4412.52	2470.68	525.93	10.18	6.20	5353.97	2755.53
V/B BU8Y PKG LWR S	250.00	10.18	5.70	2545.00	1550.00	444.44	10.18	5.70	4524.40	2755.53
V/B SPHERES LWR P	204.00	10.18	5.70	2076.72	1060.80	362.67	10.18	5.70	3691.98	1885.88
V/B SPHERES LWR S	433.45	10.18	5.70	4412.52	2470.68	525.93	10.18	5.70	5353.97	2755.53
V/B SPHERES LWR S	300.80	6.78	1.42	2039.42	427.14	265.00	6.78	1.42	1796.70	376.30
V/B SPHERES LWR S	300.80	6.78	1.42	2039.42	427.14	265.00	6.78	1.42	1796.70	376.30
V/B SPHERES LWR S	25.00	9.16	4.31	229.00	107.75	3.24	9.16	4.31	29.68	13.96
V/B PUMP	86.00	5.15	1.00	442.90	86.00	14.72	5.15	1.00	75.81	14.72
V/B PUMP MOTOR	150.00	5.15	1.00	772.50	150.00	88.96	5.15	1.00	458.14	88.96
SHUT OFF VALVE	11.70	9.00	1.75	105.30	20.47	2.18	9.00	1.75	19.62	3.81
FLOAT SWITCH	18.00	5.15	1.00	92.70	18.00	1.92	5.15	1.00	9.89	1.92
TANK RELIEF VALVE	1.50	9.00	1.75	13.50	2.63	.00	.00	.00	.00	.00
VALVE FRAME, PIPING	20.00	9.83	3.38	196.60	67.60	.00	.00	.00	.00	.00
4-WAY VALVE	5.00	11.33	4.42	56.65	22.10	.00	.00	.00	.00	.00
BY-PASS VALVE	11.70	10.17	3.04	118.99	35.57	2.18	10.17	3.04	22.17	6.63
PB VALVE	5.40	10.13	4.46	54.70	24.08	.00	10.13	4.46	.00	.00
FLOW METER	21.00	10.96	2.88	230.16	60.48	2.96	10.96	2.88	32.44	8.52
PUMP RELIEF VALVE	1.50	10.25	3.96	15.38	5.94	.00	.00	.00	.00	.00
CHECK VALVE	1.90	10.58	4.44	20.10	8.44	.00	.00	.00	.00	.00
HYDR CONTRL 88X	195.00	9.04	4.52	1762.80	881.40	142.22	9.04	4.52	1285.67	642.83
MOTOR PLMP FRAME	15.00	5.15	1.00	77.25	15.00	.00	.00	.00	.00	.00
HG SPHERES FWD (2)	26.00	1.79	1.90	46.54	49.40	41.70	1.79	1.90	74.64	79.23
HG FRAME FWD FWD	12.00	1.79	1.90	21.48	22.80	4.54	1.79	1.90	8.13	8.63
HG SPHERES AFT (2)	5.00	1.79	1.90	8.95	9.50	8.00	1.79	1.90	14.32	15.20
HG FRAME AFT	26.00	17.50	3.92	455.00	101.92	41.70	17.50	3.92	729.75	163.46
HG FWD	10.00	17.50	3.92	175.00	39.20	3.78	17.50	3.92	66.15	14.82
	245.25	1.79	1.90	439.00	465.97	.00	1.79	1.90	.00	.00

ALVIN WEIGHT AND STABILITY COMPUTATIONS
(CONTINUED)
AFTERBODY

PAGE 2

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
HG AFT	245.25	17.50	3.92	4291.88	961.38	.00	17.50	3.92	.00	.00
HG SYSTEM PLUMBING	25.00	11.00	2.00	275.00	50.00	5.00	11.00	2.00	55.00	10.00
SKIDS & BOLTS(2 STS)	46.50	8.67	1.25	403.15	11.63	17.60	8.67	1.25	152.59	4.40
SPHERE REL. GUIDES(2	19.00	4.50	1.20	85.50	22.80	2.50	4.50	1.20	3.00	3.00
SPHERES REL DOGS, ET	33.00	4.50	1.20	148.50	39.60	4.36	4.50	1.20	19.62	5.23
SPHERE FCSTLS & PADS	13.50	4.50	2.00	60.75	27.00	5.10	4.50	2.00	22.95	10.20
SPHERE RELEASE SWIMS	3.50	4.50	1.50	11.35	1.25	.95	4.50	1.50	4.27	.47
PROPULSION BOX & BIL	849.00	13.50	2.30	11461.50	1952.70	510.00	13.50	2.30	6885.00	1173.00
PROP BOX PT0 MDC	12.00	13.50	2.30	162.00	27.60	.00	.00	.00	.00	.00
PROP BOX SUPPORTS	8.00	13.50	2.30	108.00	18.40	2.00	13.50	2.30	27.00	4.60
PROP BOX FRAME SUPP	3.00	13.50	2.30	40.50	6.90	1.00	13.50	2.30	13.50	2.30
FRAME REAR SPI STS,	35.50	15.75	2.42	559.13	85.51	12.00	15.75	2.42	189.00	29.04
CONK HALVES LOWER	35.00	4.50	2.00	157.50	70.00	14.22	4.50	2.00	63.99	28.44
LIFT PRBP UNITS,BOX	382.00	9.00	7.00	3438.00	2960.50	232.00	9.00	7.00	2088.00	1798.00
LIFT PRBP BOX BIL	127.00	20.20	4.63	1143.00	984.25	.00	20.20	4.63	.00	.00
STERN PRBP ASSEMBLY	950.00	20.20	4.63	19190.00	4398.50	458.00	20.20	4.63	9251.60	2120.54
STERN PRBP BIL	82.68	20.20	4.63	1670.14	382.81	.00	20.20	4.63	.00	.00
BATTERY BOX FWD	73.50	8.68	2.80	681.38	219.80	733.03	8.68	2.80	6362.70	2052.48
BATT BOX COVER,ETC	15.00	8.68	2.80	130.20	65.70	13.71	8.68	2.80	119.00	60.05
BATT BOX EXT FRAME	76.75	8.68	2.80	666.19	214.90	29.00	8.68	2.80	251.72	81.20
BATTERIES(15260#)	900.00	8.68	2.80	7812.00	2520.00	.00	.00	.00	.00	.00
BATT BOX BIL	235.00	8.68	2.80	2039.80	658.00	.00	.00	.00	.00	.00
BATT INT RACKS,ETC	36.00	8.68	2.80	312.48	100.80	.00	.00	.00	.00	.00
BATT FUSES,WIRE,ETC	10.00	8.68	2.80	86.80	28.00	.00	.00	.00	.00	.00
BATT BOX GASKET	2.00	8.68	4.32	17.36	8.66	.00	.00	.00	.00	.00
BATTERY BOX MID	78.50	10.00	4.38	785.00	219.80	733.03	10.00	4.38	7330.30	2052.48
BATT BOX COVER,ETC	15.00	10.00	4.38	150.00	65.70	13.71	10.00	4.38	137.10	60.05
BATT BOX EXT FRAME	76.75	10.00	2.80	767.50	214.90	29.00	10.00	2.80	290.00	81.20
BATTERIES(15260#)	900.00	10.00	2.80	9000.00	2520.00	.00	.00	.00	.00	.00
BATT BOX BIL	235.00	10.00	2.80	2350.00	658.00	.00	.00	.00	.00	.00
BATT INT RACKS,ETC	36.00	10.00	2.80	360.00	100.80	.00	.00	.00	.00	.00
BATT FUSES,WIRE,ETC	10.00	10.00	2.80	100.00	28.00	.00	.00	.00	.00	.00
BATT BOX GASKET	2.00	10.00	4.32	20.00	8.66	.00	.00	.00	.00	.00
BATTERY BOX AFT	78.50	11.40	2.80	894.90	219.80	733.03	11.40	2.80	8356.54	2052.48
BATT BOX COVER,ETC	15.00	11.40	4.38	171.00	65.70	13.71	11.40	4.38	156.29	60.05
BATT BOX EXT FRAME	76.75	11.40	2.80	874.95	214.90	29.00	11.40	2.80	330.60	81.20
BATTERIES(15260#)	900.00	11.40	2.80	10260.00	2520.00	.00	.00	.00	.00	.00
BATT BOX BIL	235.00	11.40	2.80	2679.00	658.00	.00	.00	.00	.00	.00
BATT INT RACKS,ETC	36.00	11.40	2.80	410.40	100.80	.00	.00	.00	.00	.00
BATT FUSES,WIRE,ETC	10.00	11.40	2.80	114.00	28.00	.00	.00	.00	.00	.00

ALVIN WEIGHT AND STABILITY COMPUTATIONS
(CONTINUED)

AFTERBODY

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
BATT BOX GASKET	2.00	11.40	4.33	22.80	8.66	.00	.00	.00	.00	.00
BATTERY CROPS(2) FWD	56.00	8.68	3.03	486.08	169.68	7.15	8.68	3.25	62.06	23.24
BATTERY CROPS(2) MID	56.00	10.00	3.03	560.00	169.68	7.15	10.00	3.25	71.50	23.24
BATTERY CROPS(2) AFT	56.00	11.40	3.03	638.40	169.68	7.15	11.40	3.25	81.51	23.24
SPHERE SUP SYNTAC(2)	3.00	4.30	2.00	12.90	6.00	4.80	4.30	2.00	20.64	9.60
FRAME SYNTACTIC(9)	17.00	9.00	3.50	153.00	59.50	27.20	9.00	3.50	244.80	95.20
V/B BOX BRKT	1.50	17.50	5.00	26.25	7.50	.56	17.50	5.00	9.80	2.80
LWR BASKET	4.50	4.00	.30	18.00	1.35	1.70	4.00	.30	6.80	.51
WT BSKT REL BRKT 3	2.00	4.62	2.75	9.24	5.50	.76	4.62	2.75	3.51	2.09
V/B SPHERE BRAC (2)	4.00	6.78	1.42	13.56	2.84	.76	6.78	1.42	5.15	1.08
CTR V/B PKG BRAC 2	2.00	10.50	5.00	42.00	20.00	1.52	10.50	5.00	15.96	7.60
BUBY PKG HOLDDBNS 6	3.00	15.00	5.00	45.00	15.00	1.13	15.00	5.00	16.95	5.65
H01STING PIN	2.50	12.50	7.44	31.25	18.60	.95	12.50	7.44	11.87	7.07
FWD FRAME SIDE BDS(2)	22.50	7.00	1.50	187.50	33.75	11.90	7.00	1.50	83.30	17.85
FRAME SIDE BD SKIN(2)	11.50	7.00	1.50	80.50	17.25	6.10	7.00	1.50	42.70	9.15
TIE DOWNS (4)	20.00	13.50	4.67	270.00	93.40	7.40	13.50	4.67	99.90	34.56
HANDLING PADS(6)	15.00	5.00	6.50	120.00	97.50	1.98	8.00	6.50	15.84	12.87
BATTERY CHG CABLE TR	10.00	10.70	7.67	107.00	78.30	3.70	10.70	7.67	39.59	28.97
BATTERY CHG CABLES	14.50	10.70	7.67	155.15	111.21	7.25	10.70	7.67	77.57	55.61
MARSH MARINE CABLES	62.50	9.35	4.67	584.37	291.87	31.25	9.35	4.67	292.19	145.94
INSTRUMENT CASE	17.00	6.30	.83	107.10	14.11	3.54	6.30	.83	21.04	2.77
BOTTOM WINDOW CONE	12.50	3.50	1.00	43.75	12.50	6.95	3.50	1.00	24.32	6.95
FWD WT CRBP, SOL	10.50	4.50	3.00	-2.63	31.50	3.50	4.50	3.00	-1.88	10.50
PORT WT CRBP, SOL FWD	10.10	4.50	3.00	45.45	30.30	3.40	4.50	3.00	15.30	10.20
STBC WT CRBP, SOL FWD	10.10	6.00	3.00	45.45	30.30	3.40	4.50	3.00	15.30	10.20
PORT WT CRBP, SOL AFT	10.10	6.00	3.00	60.60	30.30	3.40	6.00	3.00	20.40	10.20
STBC WT CRBP, SOL AFT	10.10	6.00	3.00	60.60	30.30	3.40	6.00	3.00	20.40	10.20
BATTERY RESERVE/IR B0	182.00	7.00	1.40	1274.00	254.80	215.10	7.00	1.40	1505.70	301.14
BATTERY RES BOX BAG	32.00	7.00	1.40	224.00	44.80	17.60	7.00	1.40	124.60	24.92
BATTERY RES BOX BRKT	1.40	7.00	1.40	9.80	1.96	.37	7.00	1.40	2.59	.52
RUBBER GASKETS(3)	10.00	4.50	2.60	45.00	26.00	8.33	4.50	2.60	37.48	21.66
MISC PLUMBING	24.00	10.10	3.67	242.40	88.08	3.14	10.10	3.67	31.71	11.52
FATHOMETER	31.50	5.50	2.25	173.25	70.88	15.50	5.50	2.25	85.25	34.88
SYNT FWC SKIDS	22.00	6.50	.25	143.00	51.50	39.00	6.50	.25	253.50	9.75
CONTR CTR BOX	50.40	10.40	3.20	524.16	161.28	37.00	10.40	3.20	3848.00	1184.00
CONTR CTR COVER	14.60	10.40	3.20	151.84	46.72	.00	.00	.00	.00	.00
CONTR CTR INT PANELS	82.00	10.40	3.20	852.80	262.40	.00	.00	.00	.00	.00
CONTRBL CTR 01L	260.00	10.40	3.20	2700.00	832.00	.00	.00	.00	.00	.00
MISC FITTINGS	25.00	10.40	3.20	260.00	80.00	.00	.00	.00	.00	.00
SMALL BUDY PKGS AFT	103.00	17.28	5.38	1779.84	554.14	183.11	17.28	5.38	3164.14	985.13

ALVIN WEIGHT AND STABILITY COMPUTATIONS

(CONTINUED)

AFTERBODY

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
SYNT AFT SKIDS	21.93	10.50	.25	230.26	5.48	38.98	10.50	.25	409.29	9.74
AMF XPDR CASE	80.00	9.83	4.12	786.40	329.60	45.00	9.83	4.12	442.35	185.40
AMF XPDR HEAD	8.00	17.12	5.12	136.96	40.96	5.82	17.12	5.12	99.64	29.80
AUX BATT BOX BRKT	23.50	15.87	1.96	372.94	46.06	8.88	15.87	1.96	140.93	17.40
SS INSERTS, BOLTS	4.00	16.03	3.17	64.12	12.68	.50	16.03	3.17	8.01	1.58
BASKET ELECT DISC	15.00	.67	2.00	10.05	30.00	4.87	.67	2.00	3.26	9.74

AFTERBODY

SUMMARY	NO. ITEMS	SUM W	S	MXW	S	MYW	SUM MX	SUM MY	SUM D	S	MXPD	S	MYPD	SUM MXP	SUM MYP
126		15635.46		11.21		3.97	175221.95	62125.40	14350.48		11.54		4.55	165666.81	65312.99

BG LONGITUDINAL .34

BG VERTICAL .58

ALVIN WEIGHT AND STABILITY COMPUTATIONS

PAGE 1

VARIABLE LOAD(NORMAL)

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
MECHANICAL ARM	438.55	-2.30	2.70	-131.56	1184.08	143.00	.00	2.70	.00	386.10
MECH ARM REL	96.50	.80	3.00	77.20	289.50	30.50	.80	3.00	24.40	91.50
MECH ARM CONTR BOX	13.00	1.00	7.00	19.00	70.00	.00	1.00	7.00	.00	.00
ARM OFFSET BRKTS	13.00	1.00	3.00	13.00	39.00	3.00	1.00	3.00	3.00	9.00
SAMPLE TRAY, T80LS	150.00	-2.50	1.40	-375.00	210.00	45.00	-2.50	1.40	-112.50	63.00
PERSONNEL (3)	500.00	5.86	4.13	2930.00	2065.00	.00	.00	.00	.00	.00
ASCENT WEIGHT	500.00	4.50	2.60	2250.00	1300.00	45.00	4.50	2.60	202.50	117.00
ADD LEAD OR PAYLOAD	215.00	4.00	3.00	860.00	645.00	.00	.00	.00	.00	.00

VARIABLE LOAD(NORMAL)

SUMMARY	NO. ITEMS	SUM W	S MXW	S MYW	SUM MX	SUM MY	SUM D	S MXP	S MYP	SUM MXP	SUM MYP
8		1923.05	2.93	3.02	5633.63	5802.58	266.50	.44	2.50	117.40	666.60
BG LONGITUDINAL		-2.49			BG VERTICAL	-0.52					

ALVIN WEIGHT AND STABILITY COMPUTATIONS

PAGE 1

RELEASED FOREBODY

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
SPHERE ONLY	8331.11	4.37	4.73	36372.21	39404.13	10780.82	4.47	4.74	48239.98	51065.38
OTHER FOREBODY	6228.40	3.80	6.28	23641.00	39122.26	6721.57	3.52	6.19	24361.57	41617.48
PERSANNE (3)	500.00	5.86	4.13	2930.00	2065.00	.00	.00	.00	.00	.00
MECH ARM CNTR BxX	10.00	1.00	7.00	10.00	70.00	.00	.00	.00	.00	.00

RELEASED FOREBODY

SUMMARY	NO. ITEMS	SUM W	S	MXW	S	MYW	S	MXPD	S	MYPD	S	SUM MXP	SUM MYP
	4	15069.51		4.18		5.35		4.15		5.30		72601.55	92682.86

BG LENGTHUDINAL .03

BG VERTICAL -.06

ALVIN WEIGHT AND STABILITY COMPUTATIONS

ENTIRE VEHICLE(NORMAL)

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
SPHERE ONLY	8331.11	4.37	4.73	36372.21	39404.13	10780.82	4.47	4.74	48239.98	51065.38
OTHER FOREBODY	6228.40	3.80	6.28	23641.00	39122.26	6721.57	3.62	6.19	24361.57	41617.48
AFTERBODY	15635.46	11.21	3.97	175221.95	62125.40	14350.48	11.54	4.55	165666.81	65312.99
VARIABLE LOAD(NORMAL)	1923.05	2.93	3.02	56333.63	5802.58	266.50	.44	2.50	117.40	666.60

ENTIRE VEHICLE(NORMAL)

SUMMARY	NO. ITEMS	SUM W	S	MXW	S	MYW	S	SUM MX	SUM MY	SUM D	S	MXPD	S	MYPD	S	SUM MXP	SUM MYP
	4	32118.02	7.50	4.56	240868.79	146454.38	32119.37	7.42	4.94	238385.77	158662.45						

BG LONGITUDINAL --.08

BG VERTICAL .38

ALVIN WEIGHT AND STABILITY COMPUTATIONS

EMERGENCY CONDITIONS (1)

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
IN NORMAL CONDITION	32118.02	7.50	4.56	240868.79	146454.38	32119.37	7.42	4.94	238385.77	158662.45
BLOW M/B FBDY	-1346.00	4.50	6.00	-6057.00	-8076.00	.00	.00	.00	.00	.00
BLOW M/B AFTBDY	-300.00	10.25	6.83	-3075.00	-2049.00	.00	.00	.00	.00	.00

EMERGENCY CONDITIONS (1)

SUMMARY	NO. ITEMS	SUM W	S	MXW	S	MYW	S	SUM MX	SUM MY	SUM D	S	MXPD	S	MYPD	SUM MXP	SUM MYP
3		30472.02		7.60		4.47		231736.79	136329.38	32119.37		7.42		4.94	238385.77	158662.45
BG LONGITUDINAL		.18						BG VERTICAL	.47							

ALVIN WEIGHT AND STABILITY COMPUTATIONS
EMERGENCY CONDITIONS (2)

IDENTIFICATION	K	X	Y	MX	MY	D	XP	YP	MP	MYP
IN NORMAL CONDITION	3218.02	7.50	4.56	240868.79	146454.38	32119.37	7.42	4.94	238385.77	158662.45
DROB MIC BATTERY	-1356.63	10.00	3.19	-13566.30	-4327.65	-775.74	10.00	3.19	-7757.40	-2474.61

EMERGENCY CONDITIONS (2)

SUMMARY	NO.	ITEMS	SUM W	S	MXW	S	MYW	SUM MX	SUM MY	SUM D	S	MPD	S	MPD	SUM MPD	SUM MYP
	2		30761.39		7.39		4.62	227302.49	142126.73	31343.63		7.36		4.98	230628.37	156187.84
BG LONGITUDINAL			.003					BG VERTICAL	.36							

ALVIN WEIGHT AND STABILITY COMPUTATIONS EMERGENCY CONDITIONS (3)

PAGE 1

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
IN NORMAL CONDITION	32118.02	7.50	4.56	240868.79	14654.38	32119.37	7.42	4.94	238385.77	158662.45
DROP FWD BATTERY	-1356.63	8.68	3.19	-11775.55	-4327.65	-775.74	8.68	3.19	-6733.42	-2474.61
DROP AFT BATTERY	-1356.63	11.40	3.19	-15465.58	-4327.65	-775.74	11.40	3.19	-8843.44	-2474.61

EMERGENCY CONDITIONS (3)

SUMMARY	NO. ITEMS	SUM W	S MXW	S MYW	SUM MX	SUM MY	SUM D	S MXP	S MYP	SUM MXP	SUM MYP
	3	29404.76	7.27	4.69	213627.66	137799.08	30567.89	7.29	5.03	222808.91	153713.23
BG LONGITUDINAL		.02			BG VERTICAL	.34					

ALVIN WEIGHT AND STABILITY COMPUTATIONS

PAGE 1

EMERGENCY CONDITIONS (4)

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
IN NORMAL CONDITION	32118.02	7.50	4.56	240868.79	146454.38	32119.37	7.42	4.94	238385.77	158662.45
DRBP FWD BATTERY	-1356.63	8.68	3.19	-11775.55	-4327.65	-775.74	8.68	3.19	-6733.42	-2474.61
DRBP MID BATTERY	-1356.63	10.00	3.19	-13566.30	-4327.65	-775.74	10.00	3.19	-7757.40	-2474.61
DRBP AFT BATTERY	-1356.63	11.40	3.19	-15465.58	-4327.65	-775.74	11.40	3.19	-8843.44	-2474.61

EMERGENCY CONDITIONS (2)

SUMMARY	NB. ITEMS	SUM W	S	MXW	S	MYW	S	SUM MX	SUM MY	SUM D	S	MXPD	S	MYPD	S	SUM MXP	SUM MYP
		28048.13		7.13		4.76		200061.36	133471.43	29792.15		7.22		5.08		215051.51	151238.62

BG LONGITUDINAL .09

BG VERTICAL .32

ALVIN WEIGHT AND STABILITY COMPUTATIONS

EMERGENCY CONDITIONS (6)

IDENTIFICATION	W	X	Y	MX	MY	D	XP	YP	MXP	MYP
IN NORMAL CONDITION	32118.02	7.5C	4.56	240868.79	146454.38	32119.37	7.42	4.94	238385.77	158662.45
FLC8D V/2 SPHERES	265.00	9.05	4.27	2398.25	1131.55	.00	.00	.00	.00	.00
DR8P FMC BATTERY	-1356.63	8.68	3.19	-11775.55	-4327.65	-775.74	8.68	3.19	-6733.42	-2474.61
DR8P MID BATTERY	-1356.63	10.0C	3.19	-13566.30	-4327.65	-775.74	10.00	3.19	-7757.40	-2474.61
DR8P AFT BATTERY	-1356.63	11.4C	3.19	-15465.58	-4327.65	-775.74	11.40	3.19	-8843.44	-2474.61
DR8P ARM	-438.55	-3C	2.70	131.56	-1184.08	-143.00	.00	2.70	.00	-386.10

EMERGENCY CONDITIONS (6)

SUMMARY	NO. ITEMS	SUM W	S	MXW	S	MYW	S	SUM MX	SUM MY	SUM D	S	MXPD	S	MYPD	S	SUM MXP	SUM MYP
	6	27874.58		7.27		4.79		202591.17	133418.90	29649.15		7.25		5.09		215051.51	150852.52

STOP C BG LONGITUDINAL -.01

BG VERTICAL .30

End of Computer Printout

III. Tethered Trim Dive and Inclining Experiments

On March 23, 1975 the tethered trim dive and the surface and submerged inclining experiments were performed at the W.H.O.I. dock in Woods Hole. During the tethered trim dive, a minor malfunction in the variable ballast system made it impossible to flood the VB spheres sufficiently to reach the neutrally buoyant condition. So that the tests could be continued, neutral buoyancy was achieved by adding calibrated steel weights to the sponsons of ALVIN.

To complete the trim dive, a Martin-Decker 0-500 lb. scale and a light bridle were used to tether ALVIN to a small crane aboard LULU. Steel plates weighing 46 lbs. each (40 lbs. in water) were added to the ALVIN sponsons and forward deck area until an average scale reading of just under 50 lbs. was obtained. One steel plate was then removed and the submarine was very nearly neutral. A total of 14 steel weights (560 lbs.) were placed aboard. The load to submerge is computed as follows:

Flood Main Ballast Fwd	1346 lbs.
Flood Main Ballast Aft	300 lbs.
Flood Variable Ballast	<u>560 lbs.</u>
Total Load to Submerge	2206 lbs.

The submerged inclining experiment was performed with the external weights aboard as described above. Six of the steel plates were used as inclining weights.

During this test a strong tidal current necessitated an almost constant tension on ALVIN's handling lines, and equilibrium readings of inclination angles were difficult to obtain. A slight vehicle list angle was present at the start of the test, due probably to unequal distribution of the added weights. The initial list angle caused the plot of tangents to be offset from the zero point, and the inclinometer pointer reached the end of its travel before the last two readings could be taken. However, five points were obtained, and these were plotted to produce quite a good straight line. Using the slope of this curve, the value of the vertical component of the BG distance was found to be 0.28 ft. The effect on the location of the center of gravity G, of adding weights relatively high on the submarine instead of flooding the VB tanks (as would normally have been done) was investigated. It was found that the use of topside weights caused G to be moved upward 0.08 ft. This was applied as a correction to the already determined value of BG to give

$$BG = 0.28 + 0.08 = 0.36 \text{ ft.}$$

Because of the difficulties caused by the current in the harbor, the submerged roll-period test was not done on this date.

The surface inclining experiment was done with both main ballast tanks blown and only six inclining weights aboard. The test proceeded as planned and a good plot of tangents was obtained. A value $GM = 0.59$ ft. was determined using the slope of the plot.

The induced rolling (sallying) test consisted of measuring the elapsed time for four successive cycles of roll. The value of GM thus obtained was 0.61 ft.

Detailed calculations are shown on the following pages.

Submerged Inclining Experiment
Data Form

1. Data recorded on this form are specifically for the submerged portion of the inclining trials; the previous form contains all other data.

a. Weights and angles

<u>Movement</u>	<u>Weight</u> <u>Lbs. Net</u>	<u>Moment</u> <u>Ft. Lbs.</u>	<u>Tan θ</u>
All Wt. P	-240.38	-841.35	.020 P
1 Wt P-S	-160.40	-561.40	.015 S
1 Wt P-S	-78.68	-275.38	.050 S
1 Wt P-S	.43	1.52	.070 S
1 Wt P-S	80.41	281.47	.110 S (Est.)
1 Wt P-S	-	-	-
1 Wt P-S	-	-	-

b. Roll period

Period-Sec. (T)

1st roll	_____	
2nd roll	_____	
3rd roll	_____	
4th roll	_____	
Total	_____	
Average T	_____	T ² _____

2. Remarks:

3. Date March 23, 1975

Location W.H.O.I. Dock

Recorder

Arnold G. Sharp

Arnold G. Sharp
Trials Engineer

Figure 4. Plot of Tangents for Submerged Inclining Experiment

Surface Inclining Experiment

Data Form

1. Data Recorded: Variable load, inclining weights, moment arms, drafts, inclinometer angles, water temperature and density, roll periods.
2. When Recorded: Variable load - prior to launch (in weight log)

Inclining weights - when placed on sponsons and when moved.

Moment arms - when weights are placed.

Drafts - after adjusting to 0° trim

Inclinometer angles - as weights are added or changed.

Roll period - while sallying ship

Water temperature and density - at end of experiment.
3. By Whom Recorded: Trials engineer or recorder
4. Data:
 - a. Draft (after adjusting to 0° trim)
Port 7'5" Stbd 7'5" Time 1435
 - b. Moment arms (ft. - in. by steel tape)

To C.G. of weights port sponson 3'6"

To C.G. of weights stbd sponson 3'6"

c. Weights and angles

<u>Movement</u>	<u>Wt.-lbs. net</u>	<u>Moment-ft.-lbs.</u>	<u>Tan θ</u>
All Wt P	<u>-240.38</u>	<u>-841.35</u>	<u>.041 P</u>
1 Wt P-S	<u>-160.40</u>	<u>-561.41</u>	<u>.030 P</u>
1 Wt P-S	<u>- 78.68</u>	<u>-275.38</u>	<u>.013 P</u>
1 Wt P-S	<u>.43</u>	<u>1.52</u>	<u>.001 S</u>
1 Wt P-S	<u>80.41</u>	<u>281.47</u>	<u>.019 S</u>
1 Wt P-S	<u>160.40</u>	<u>561.41</u>	<u>.0335 S</u>
1 Wt P-S	<u>240.38</u>	<u>841.36</u>	<u>.0475 S</u>

d. Roll period

	<u>Period-Sec. (T)</u>
1st roll	<u> </u>
2nd roll	<u> </u>
3rd roll	<u> </u>
4th roll	<u> </u>
Total	<u>17</u>
Average T	<u>4.25</u> T^2 <u>18.06</u>

e. Water temperature 38.5 °F

f. Hg distribution

Height of Hg in fwd tanks in. ;
lbs. of Hg 416.67

Height of Hg in aft tanks in. ;
lbs. of Hg 83.33

5. Remarks:

6. Date March 23, 1975 Location WHOI Dock

Recorder

Arnold G. Sharp
Trial Engineer

ALVIN SURFACE
INCLINING EXPERIMENT
March 23, 1975

$$\text{SLOPE} = \frac{525}{.030} = 17,500$$

$$\text{GM} = \frac{\text{SLOPE}}{W}$$

$$= \frac{17,500}{29,467}$$

$$= 0.59 \text{ FT.}$$

Figure 5. Plot of Tangents for Surface Inclining Experiment

Computation of Total Displacement For
Surface and Submerged Inclining Experiments

1. Normal Submerged Condition (From Computer
Weight Summary of Feb. 19, 1975) 32,064 lbs.

2. For The Surface Inclining Experiment,
Subtract The Following:

One Person	167 lbs.	
Sample Tray	150	
Ascent Wt.	500	
Add'l Payload	250	
Mech. Arm	558	
MB Water Aft	300	
MB Water Fwd	1346	
VB Water Pumped	<u>560</u>	
	3831	
		<u>-3831</u>
		28,233

And Add The Following:

Wt. Droppers, Wts.	966 lbs.	
Inclinometer	28	
Inclining Wts.	<u>240</u>	
	1234	
		<u>+1234</u>
Surfaced Condition, Mar. 23, 1975		29,467 lbs.

3. For The Submerged Inclining Experiment,
Add The Following:

MB Water Fwd	1346 lbs.	
MB Water Aft	300	
Add'l Steel		
Plates	<u>320</u>	
	1966	
		<u>+1966</u>
Submerged Condition, Mar. 23, 1975		31,433 lbs.

Calculation For Shift Of Center Of Gravity G
Due To Added Weights Topside
Submerged Inclining Experiment

	<u>W</u>	<u>Y</u>	<u>MY</u>
Normal Subm. Cond. (Comp. 2/19/75)	32063.75	4.56	146,152.19
Remove Lower VB Water	-377.60	1.42	-536.19
Remove Upper VB Water	-262.40	5.70	-1495.68
Add Equal Wt. Steel To Sponsons	+640.00	7.33	+4693.33
New Totals	32063.75		148,813.65

$$\text{New Value } Y = \frac{148,813.65}{32063.75} = 4.64 \text{ ft.}$$

$$\Delta Y = 4.64 - 4.56 = 0.08 \text{ ft.}$$

Induced Rolling (Sallying)
Surface Condition

Time for 4 complete rolls = 17 sec.

Period T = 4.25 sec.

$$T^2 = 18.06$$

Estimated radius of gyration K = 3 ft.

$$K^2 = 9$$

The metacentric height

$$\begin{aligned} GM &= \frac{1.23 K^2}{T^2} \\ &= \frac{1.23(9)}{18.06} \\ &= 0.61 \text{ ft.} \end{aligned}$$

Calculation of Water Density

Tethered Trim Dive, Surface and Submerged
Inclining Experiments, March 23, 1975

Water Temperature 38.5 deg. F.

Salinity 35 parts per thousand

Temperature in deg. C.

$$C = 5/9 (F-32)$$

$$= 5/9 (38.5 - 32)$$

$$= 3.61 \text{ deg. C.}$$

Using Sigma-T Tables (Ref. 2)

$$\sigma_t = 27.849$$

$$\text{Density} = 1.0278 \text{ grams per C.C.}$$

$$= 64.12 \text{ lbs./cu. ft.}$$

IV. Miscellaneous Calculations

Pounds Per Inch Immersion This is the weight of a layer of seawater one inch thick, whose area is equal to that of the vehicle's waterplane. It is used to obtain the change in draft for a given moderate change in weight. The increase or decrease in draft would be equal to the vehicle's weight change divided by the pounds per inch immersion. The waterplane area (A_{wp}) used here is based on draft readings observed during the surface inclining experiment done on March 23, 1975. Thus, the pounds per inch immersion

$$\begin{aligned} \text{PPI} &= A_{wp} \times \frac{1}{12} \times 64 \\ &= 75 \times \frac{1}{12} \times 64 \\ &= 400 \text{ pounds per inch} \end{aligned}$$

Moment to Heel One Degree (Submerged) This is the moment to produce an inclination of 1 degree about the longitudinal axis. It is found for the submerged vehicle by

$$\begin{aligned} \text{MHD} &= W(\text{BG}) \sin 1^\circ \\ &= 31,433 (.36) (.0175) \\ &= 198 \text{ ft.-lbs.} \end{aligned}$$

Moment to Heel One Degree (On Surface) This is the moment to produce an inclination of 1 degree about the longitudinal axis of the vehicle on the surface. It is given by

$$\begin{aligned} \text{MHD} &= W(\text{GM}) \sin 1^\circ \\ &= 29,467 (.59) (.0175) \\ &= 304 \text{ ft.-lbs.} \end{aligned}$$

Moment to Trim One Degree (On Surface) This is the moment to produce a one degree angle of inclination in a vertical plane through the longitudinal axis. During the dockside trials on March 23, 1975 the trim mercury was shifted-first completely to the forward tanks, and then completely to the after tanks. The total amount of mercury was 490.50 pounds and the distance between the forward and after tanks is 15.71 feet. The total angle change was 9.25 degrees. Therefore, the moment to trim one degree

$$\begin{aligned} \text{MTD} &= \frac{490.50 \times 15.71}{9.25} \\ &= 833 \text{ ft.-lbs.} \end{aligned}$$

V. Discussion

The following table shows the principal results obtained from the weight and stability computations, and from the dockside trials, for ALVIN in 1975.

	Vehicle Submerged	Vehicle on Surface
BG Longitudinal, ft. (computed)	-0.08	
BG Vertical, ft. (computed)	0.38	
BG Vertical, ft. (inclining)	0.36	
BG vertical, ft. (roll period)	-	
GM Vertical, ft. (inclining)		0.59
GM Vertical, ft. (roll period)		0.61

The computed BG vertical shows an increase of about 9 percent over the corresponding 1974 value (Ref. 3), and the BG vertical found in the submerged inclining experiment agrees well with the computed result. The value of BG longitudinal, as calculated by computer, does not change much from year to year. The 1974 value was -0.09 ft. (Ref. 3) while in 1973 it was -0.08 ft. (Ref. 4). This is probably due to the fact that

although some changes to the vehicle are inevitable during each overhaul period, care is taken that these changes are made in such a way that the fore-and-aft locations of the points B and G are disturbed as little as possible. The two values of GM vertical, resulting from the surface inclining experiment and the induced rolling test, agree within 3 percent. These values show a marked increase over those obtained in the most recent previous tests (Ref. 4) done in 1973 (about 25 percent for the inclining experiment results). The increase is undoubtedly due in part to the addition of the new afterbody main ballast tank. This fiberglass enclosure, with a capacity of 300 pounds of seawater, is positioned just above the two titanium alloy buoyancy spheres centrally located in the upper afterbody. Also contributing to improved surface stability is the new syntactic foam surrounding the variable ballast spheres in the upper afterbody. This foam replaces that originally installed in ALVIN; samples of the early foam recently have been weighed and found to be quite heavy, probably because of water absorption at operating depths. A gain in freeboard estimated at one inch also has resulted from the installation of the new main ballast tank and the new syntactic foam.

The vehicle total displacement now is 32,119 pounds with the "additional lead or payload" value adjusted to 215 pounds. It should be noted here that the value 32,064 pounds used in the trim dive and inclining experiment calculations was the correct computed displacement on that date. Minor modifications to the vehicle after that time necessitated a new computer run which is the one included in Section II of this report.

The new control center box is located three feet off the longitudinal axis to port, and it replaces a syntactic foam package that provided about 160 pounds of net buoyancy. This change has resulted in a port list of about 2 degrees.

VI. References

1. "Preliminary ALVIN Weight and Stability Report for 1975," by Arnold G. Sharp, W.H.O.I. Office Memorandum, February 20, 1975.
2. "Processing Oceanographic Data," by E. C. LaFond, U.S. Navy Hydrographic Office Publication No. 614, Washington, D.C., 1951.
3. "DSRV ALVIN Weight Report, 1974," by Arnold G. Sharp, W.H.O.I. Technical Memorandum No. 8-79, December 1974.
4. "DSRV ALVIN Weight Report, 1973," by Arnold G. Sharp and Kenneth W. Doherty, W.H.O.I. Technical Memorandum No. 6-73, December 1973.

VII. Appendix - Computer Program

NAME: ALVINSTA

TYPE: Main program

PURPOSE: To compute total weight and total displacement of the DSV ALVIN in its normal and various emergency conditions; weight and displacement of various subassemblies (sphere, forebody, etc.); location of center of gravity and center of buoyancy for the vehicle and for subassemblies; BG distance for the vehicle and for subassemblies expressed in longitudinal and vertical components. The program has an optional plot tape output to give graphic representation of submersibles attitude under the various conditions.

MACHINE: XDS Sigma 7

SOURCE LANGUAGE: XDS Fortran IV

PROGRAM CATEGORY: Data Processing

DESCRIPTION: A full description and an example of the input/output data may be found in W.H.O.I. Technical Memorandum DS-26, WEIGHT, BUOYANCY AND STABILITY OF DSRV ALVIN, 1967, Arnold G. Sharp, January 1968.

INPUT:

Punched Cards -- With one exception (Entire Vehicle, Normal, see below) each section of data requires one set of data cards of the following form:

Card 1: 28-character alphanumeric title
Succeeding data cards of the following format: cards (up to 300)

Columns

1-20	20-character alphanumeric identifier
22-29	W item air weight
31-35	X CG X distance
37-41	Y CG Y distance
43-50	D displacement of item
52-56	XP B X distance
58-62	YP B Y distance
64	C control integer

Last card: !EOD (after each data section)

The section titled Entire Vehicle, Normal obtains all its data input from core memory. For this section a title card and an !EOD card only are to be used.

Since output from some data sections is stored in core memory and used as input to other sections, the order of input is critical. The program requires input sections in the following order:

1. Sphere only
2. Other forebody
3. Afterbody
4. Variable load
5. Released forebody
6. Entire vehicle, Normal
7. Emergency conditions

There may be as many emergency conditions sections as desired.

The program will stop when it finds a (3) punched in column 64 of the last data card of any set, or in the title card of the Entire Vehicle, Normal set.

OUTPUT: On the line printer. Please see Technical Memorandum DS-26 for format and example program output. On calcomp plotter. Graphic representation of ALVIN in the attitude calculated by the program for a given data section.

USAGE: The deck is set up:

```
!JOB ---, ----
!MESSAGE PLOT TAPE (if needed)
!ASSIGN F:PLOT, (DEVICE, 7T), (BIN), (OUTSN, PLTL), (OUT), (UNPACK)
!FORTRAN LS, GO,X*
      (Fortran deck of ALVINSTA)
!DATA
! (Permanent data deck)
      (Data cards as described above)
      *Use "X" option only if plot is desired
```

RESTRICTIONS:

1. Column 64 contains 0 (zero) on all but the last data card in each section (before !EOD card)
2. A (2) in column 64 of the last data card of a set causes plot output for that section, except, a (2) in column 64 of the title card for the Entire Vehicle, Normal section causes plot output for that section. In either case a plot will be produced only if the option was used when the program was compiled.
3. A (3) in column 64 of the last data card indicates last section and terminates program. Plot will be output for last section unless "X" option was not specified on !FORTRAN card.

STORAGE REQUIREMENTS: About 5000₁₀ words

SUBPROGRAMS REQUIRED: AXDRAW, PLOT, SYMBOL

OPERATIONAL ENVIRONMENT:

<u>Device</u>	<u>Function</u>	<u>Special requirements</u>
card reader	input	F:105 DCB
line printer	output	F:108 DCB
7 track tape	output	F:PLOT DCB

OPERATIONAL CHARACTERISTICS:

Reads a data section then prints and writes tape (if called for).

TIMING: About 2 1/2 minutes for typical large job with plot

PROGRAMMER: Andy Eliason (modified by W. Freund).

ORIGINATOR: Arnold Sharp

DATE: July, 1971 (Modified, August, 1975)

REFERENCE: Technical Memorandum DS-26

Computer program

```
1. C*****
2. C  ALVIN WEIGHT AND STABILITY PROGRAM
3. C  JUNE 1971
4. C  PROGRAMMER: ANDREW H. ELIASON
5. C  MODIFIED BY W FREUND
6. C  AUGUST 1975
7. C  TO ELIMINATE THE NEED FOR MULTIPLE RUNS.
8. C  PROGRAM CHANGED SO THAT OUTPUT VALUES FROM SOME SECTIONS ARE
9. C  STORED INTERNALLY FOR USE AS INPUT TO LATER SECTIONS.
10. C
11. C  USE X OPTION FOR CALCULATION WITH PLOT
12. C*****
13. C
14. C  NOTE: THE PROGRAM EXPECTS INPUT AS FOLLOWS:
15. C  1 SET OF ALVIN PICTURE DATA FOLLOWED BY AN EOD CARD (OR EOD ALONE)
16. C  5 SETS OF DATA EACH PRECEDED BY A SECTION ID CARD AND
17. C  FOLLOWED BY AN EOD CARD.
18. C  1 SECTION ID CARD (ENTIRE VEHICLE-NORMAL) FOLLOWED BY AN EOD CARD.
19. C  1 TO N SETS OF EMERGENCY CONDITION DATA EACH PRECEDED BY A
20. C  SECTION ID CARD AND FOLLOWED BY AN EOD CARD.
21. C  THE PROGRAM MAY BE HALTED AFTER ANY SECTION BY PUNCHING A 3 IN
22. C  COLUMN 64 OF THE LAST DATA CARD OF THE LAST SECTION WANTED.
23. C  EXCEPT THAT - SINCE THERE IS NO CARD DATA FOR THE
24. C  ENTIRE VEHICLE-NORMAL SECTION, THE 3 SHOULD BE PUNCHED IN
25. C  COLUMN 64 OF THE SECTION ID CARD IF THE ENTIRE VEHICLE SECTION
26. C  IS THE LAST ONE WANTED.
27. C  THE PLOT OPTION (2 IN COL. 64) FOLLOWS THE SAME RULE.
28. C
29. C  PROGRAM PERFORMS WEIGHT AND STABILITY CALCULATIONS FOR
30. C  ALVIN AND ITS PARTS.
31. C  OUTPUT IS IN SECTIONS. DATA IS READ IN FOR ONE SECTION,
32. C  CALCULATIONS ARE MADE AND RESULTS PRINTED. THEN THE NEXT SECTION
33. C  DATA IS READ, ETC.
34. C
35. C  EACH SECTION PRODUCES DETAIL AND SUMMARY RESULTS.
36. C  FOR EACH SECTION OF THE OUTPUT THE OUTPUT PAGE NUMBER IS SET = 1
37. C  AND THE SECTION ID IS READ IN FROM A CARD.
38. C  SECTIONS ARE INDEPENDENT OF ONE ANOTHER EXCEPT THAT
39. C  OUTPUT FROM SOME IS INPUT TO OTHERS.
40. C
41. C  THE FIRST 4 SECTIONS ARE TITLED:
42. C      1. SPHERE ONLY
43. C      2. OTHER FOREBODY
44. C      3. AFTERBODY
45. C      4. VARIABLE LOAD
46. C
47. C  SIX OF THE SUMMARY VALUES FROM EACH OF THE FIRST FOUR SECTIONS
48. C  ARE STORED IN ARRAY STORE(6,4) FOR USE BY LATER SECTIONS.
49. C
50. C  SECTION 5 IS TITLED RELEASED FOREBODY. INPUT TO THIS SECTION
51. C  IS SUMMARY VALUES FROM SPHERE ONLY AND FOREBODY PLUS
52. C  NEW INPUT READ JUST BEFORE PROCESSING THIS SECTION.
53. C  OUTPUT FROM THIS SECTION IS NOT SAVED.
54. C
55. C  SECTION 6 IS TITLED ENTIRE VEHICLE(NORMAL). INPUT TO THIS SECTION
56. C  IS THE SUMMARY VALUES OF THE FIRST 4 SECTIONS. NO ADDITIONAL
57. C  DATA IS READ IN FOR THIS SECTION.
58. C  OUTPUT FROM THIS SECTION IS SAVED FOR INPUT TO THE FOLLOWING
59. C  SECTIONS.
```

```

60. C
61. C THE SECTIONS FOLLOWING ARE TITLED EMERGENCY CONDITIONS.
62. C THERE IS NO LIMIT TO THE NUMBER OF THESE SECTIONS.
63. C FOR EACH SECTION INPUT CONSISTS OF THE SUMMARY VALUES FROM
64. C SECTION 6 (ENTIRE VEHICLE) PLUS NEW INPUT RECORDS READ
65. C JUST BEFORE PROCESSING EACH SECTION.
66. C
67. C*****
68. C
69. C IMPLICIT DOUBLE PRECISION (A-H,O-Z)
70. C REAL X2,Y2
71. C
72. X COMMON IBUF(1000)
73. COMMON ARRAY1(500)
74. COMMON ARRAY2(500)
75. X COMMON ARRAY3(500)
76. X COMMON ARRAY4(500)
77. X SCALE= 500.0
78. C
79. COMMON IDEN(300,5),ID(7)
80. DIMENSION X(300),Y(300),W(300),D(300),XP(300),YP(300),C(300)
81. C
82. X CALL PLOTS(IBUF,-1000)
83. C
84. C*****
85. C READ ALVIN PICTURE DATA
86. C*****
87. C
88. M=1
89. 15 M1=M+3
90. READ(105,105,END=55)(ARRAY1(I),ARRAY2(I),I=M,M1)
91. 105 FORMAT (4(5X,I6,2X,I6,1X))
92. M=M+4
93. GO TO 15
94. 55 CONTINUE
95. M=M-4
96. C*****
97. C
98. C INTEGER NEED, START, SMRY
99. C INTEGER JSECT, J, L, N
100. C INTEGER NUMBER
101. C
102. C*****
103. C OUTPUT SECTIONS 1 - 4
104. C SPHERE ONLY - OTHER FOREBODY - AFTERBODY - VARIABLE LOAD
105. C ALL DATA FOR THESE SECTIONS IS READ IN SO WE START READING
106. C INTO FIRST ELEMENTS OF INPUT ARRAYS.
107. C SUMMARY VALUES ARE SAVED FOR USE BY LATER SECTIONS.
108. C THE SECTION ID'S ARE SAVED. THEY ARE USED FOR DETAIL LINE ID'S
109. C BY LATER SECTIONS.
110. C*****
111. C
112. C REPEAT 5, FOR JSECT = (1,4)
113. C IPAGE = 1
114. C READ(105,900) ID
115. C CALL RDATA(1)
116. C CALL CALCPRINT
117. C CALL SAVE(JSECT)
118. X CALL PICTURE
119. IF(C(N).EQ.3) STOP

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120.      5      CONTINUE
121.      C
122.      C*****
123.      C      OUTPUT SECTION 5 - RELEASED FOREBODY.
124.      C      WE GET FIRST 2 RECORDS FROM CORE THEN START READING INTO
125.      C      ELEMENT 3 OF INPUT ARRAYS.
126.      C*****
127.      C
128.          IPAGE = 1
129.          READ(105,900) ID
130.          CALL COREID(2)
131.          CALL COREDATA(2)
132.          CALL RDATA(3)
133.          CALL CALCPRINT
134.      X      CALL PICTURE
135.          IF(C(N).EQ.3) STOP
136.      C
137.      C*****
138.      C      OUTPUT SECTION 6 - ENTIRE VEHICLE NORMAL.
139.      C      ALL 4 RECORDS FOR THIS SECTION COME FROM CORE.
140.      C      SINCE NO DATA IS READ HERE WE GET PICTUR/STOP CODE FROM ID CARD.
141.      C      SAVE SUMMARY DATA FROM THIS SECTION.
142.      C*****
143.      C
144.          IPAGE = 1
145.          N = 4
146.          READ(105,901) ID, C(N)
147.          READ(105,901,END=6)
148.      6      CONTINUE
149.          CALL COREID(4)
150.          CALL COREDATA(4)
151.          N = 4
152.          CALL CALCPRINT
153.          CALL SAVE(1)
154.      X      CALL PICTURE
155.          IF(C(N).EQ.3) STOP
156.      C
157.      C*****
158.      C      OUTPUT SECTIONS 7 TO N - EMERGENCY CONDITIONS.
159.      C      THERE IS NO LIMIT TO THE NUMBER OF THESE SECTIONS.
160.      C      END RUN WITH 3 IN COL. 64.
161.      C      WE GET FIRST INPUT RECORD FROM CORE, THEN WE READ.
162.      C      START READING INTO ELEMENT 2 OF INPUT ARRAYS.
163.      C
164.      C*****
165.      C
166.      C      ID OF FIRST DETAIL LINE IS THE SAME FOR ALL OF THESE.
167.      C      INTEGER EMLINE(5) // IN NORMAL CONDITION //
168.      C      REPEAT 7, FOR J = (1,5)
169.      C          IDEN(1,J) = EMLINE(J)
170.      7      CONTINUE
171.      C
172.      C      INTEGER GO/O/
173.      C      REPEAT 10, WHILE GO.EQ.C
174.          IPAGE = 1
175.          READ(105,900) ID
176.          CALL COREDATA(1)
177.          CALL RDATA(2)
178.          CALL CALCPRINT
179.      X      CALL PICTURE

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180.      IF(C(N).EG.3) STOP
181. 10 CONTINUE
182. C
183. 900 FORMAT(7A4)
184. 901 FORMAT(7A4, T64, I1)
185. C
186. C*****
187. SUBROUTINE PDATA(START)
188. C*****
189. C
190. REPEAT 5, FOR N = (START, 300)
191. READ(105,100,END=7)
192. X (IDEN(N,J), J=1,5),
193. X W(N), X(N), Y(N), D(N), XP(N), YP(N), C(N)
194. 5 CONTINUE
195. C
196. 7 CONTINUE
197. N = N - 1
198. RETURN
199. C
200. 100 FORMAT(5A4,1X,F8.2,2(1X,F5.2),1X,F8.2,2(1X,F5.2),1X,I1)
201. C
202. C*****
203. SUBROUTINE SAVE(SMRY)
204. C*****
205. C
206. DOUBLE PRECISION STORE(6,4)
207. INTEGER IDSTORE(4,5)
208. C
209. REPEAT 5, FOR L = (1,5)
210. IDSTORE(SMRY,L) = ID(L)
211. 5 CONTINUE
212. C
213. STORE(1,SMRY) = SW
214. STORE(2,SMRY) = SRXW
215. STORE(3,SMRY) = SRYW
216. STORE(4,SMRY) = SD
217. STORE(5,SMRY) = SRXPD
218. STORE(6,SMRY) = SRYPD
219. C
220. RETURN
221. C
222. C*****
223. SUBROUTINE COREID(NUMBER)
224. C*****
225. C
226. REPEAT 5, FOR N = (1,NUMBER)
227. REPEAT 3, FOR L = (1,5)
228. IDEN(N,L) = IDSTORE(N,L)
229. 3 CONTINUE
230. 5 CONTINUE
231. C
232. RETURN
233. C
234. C*****
235. SUBROUTINE COREDATA(NEED)
236. C*****
237. C
238. REPEAT 5, FOR N = (1, NEED)
239. C

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240.      W(N) = STORE(1,N)
241.      X(N) = STORE(2,N)
242.      Y(N) = STORE(3,N)
243.      D(N) = STORE(4,N)
244.      XP(N) = STORE(5,N)
245.      YP(N) = STORE(6,N)
246.  C
247.  5  CONTINUE
248.      RETURN
249.  C
250.  C*****
251.      SUBROUTINE CALCPRINT
252.  C*****
253.  C
254.      WRITE(108,200) IPAGE,WRITE(108,250) ID,WRITE(108,300)
255.      ITEM = 1
256.      SW=0.0;SRXW=0.0;SRYW=0.0;SRX=0.0;SRY=0.0;SD=0.0;SRXPD=0.0;SRYPD=0.0
257.      SRXP=0.0;SRYP=0.0
258.  C
259.  C  CALCULATE RESULTS
260.      DO 30 I=1,N
261.          RX=W(I)*X(I);RY=W(I)*Y(I)
262.          RXP=D(I)*XP(I);RYP=D(I)*YP(I)
263.          SW=W(I)+SW;SD=D(I)+SD
264.          SRX=SRX+RX;SRY=SRY+RY;SRXP=SRXP+RXP;SRYP=SRYP+RYP
265.          SRXW=SRX/SW;SRYW=SRY/SW
266.          SRXPD=SRXP/SD;SRYPD=SRYP/SD
267.          BGL=SRXPD-SRXW;BGV=SRYPD-SRYW
268.  C
269.      WRITE(108,400)(IDEN(I,J),J=1,5),W(I),X(I),Y(I),RX,RY,D(I),XP(I),
270.      1 YP(I),RXP,RYP
271.  C
272.      IF(ITEM.EQ.40.0R.ITEM.EG.80.0R.ITEM.EQ.120) IPAGE=IPAGE+1,
273.      1 WRITE(108,200) IPAGE,WRITE(108,260) ID,WRITE(108,300)
274.  C
275.      ITEM=ITEM+1
276.  30 CONTINUE
277.  C
278.  C  PRINT RESULTS
279.      WRITE(108,950) ID
280.      WRITE(108,500)
281.      WRITE(108,600) N,SW,SRXW,SRYW,SRX,SRY,SD,SRXPD,SRYPD,SRXP,
282.      1SRYP,WRITE(108,700) BGL,BGV, IPAGE=IPAGE+1
283.  C
284.      RETURN
285.  C
286.  200 FORMAT(1H1,
287.      X 46X, 'ALVIN WEIGHT AND STABILITY COMPUTATIONS',
288.      X 35X, 'PAGE ', I1/)
289.  C
290.  250 FORMAT(46X,7A4/)
291.  C
292.  260 FORMAT (46X,7A4, ' (CONTINUED)',/)
293.  C
294.  300 FORMAT(3X,'IDENTIFICATION',11X,'W',9X,'X',8X,'Y',9X,'MX',10X,'MY',
295.      111X,'D',9X,'XP',7X,'YP',8X,'MXP',9X,'MYP',/)
296.  C
297.  400 FORMAT(1X,5A4,4X,F8.2,2(4X,F5.2),3(3X,F9.2),2(4X,F5.2),2(3X,F9.2))
298.  C
299.  500 FORMAT(//, 'SUMMARY  NO. ITEMS',6X,'SUM W',4X,'S MXW',4X,'S MYW',

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300.      16X,'SUM MX',6X,'SUM MY',7X,'SUM D',5X,'S MXP',3X,'S MYP',4X,'SUM
301.      1 MXP',5X,'SUM MYP')
302.      C
303.      60C FORMAT(14X,I3,8X,F8.2,2(4X,F5.2),3(3X,F9.2),2(4X,F5.2),2(3X,F9.2))
304.      C
305.      70C FORMAT(/,10X,'BG LONGITUDINAL',5X,F5.2,20X,'BG VERTICAL',5X,F5.2)
306.      C
307.      80C FORMAT('1')
308.      C
309.      95C FORMAT(/,1X,7A4)
310.      C
311.      C*****
312.      X      SUBROUTINE PICTURE
313.      C*****
314.      C      CALCULATE PICTURE ROTATION DATA
315.      X      IF(C(N).LT.2) GO TO 80
316.      X      THETA =DATAN2(SRXPDSRXL,SRYPD-SRYW)
317.      X      DO 25 I=1,M
318.      X      IF(ARRAY2(I).GT.3000) ARRAY4(I)= 10500, GO TO 25
319.      X      X1= ARRAY1(I)
320.      X      Y1= ARRAY2(I)
321.      X      GAMMA=DATAN2(Y1,X1)
322.      X      R =DSGRT(X1**2+Y1**2)
323.      X      A = GAMMA + THETA
324.      X      X1= R*DCOS(A)
325.      X      Y1= R*DSIN(A)
326.      X      ARRAY3(I)=X1
327.      X      ARRAY4(I)=Y1
328.      X 25 CONTINUE
329.      C*****
330.      C      PLOT ALVIN PICTURE
331.      X      CALL PLOT(10.0,10.0,-3)
332.      X      CALL AXDRAW(-6.0,0.0,'X',1,16.0,0.0,-6.0,1.0,1.0,-1)
333.      X      CALL AXDRAW(0.0,-4.0,'Y',-1,10.0,90.0,-4.0,1.0,1.0,-1)
334.      X      CALL SYMBOL (-7.,-9.,21,10,0,28)
335.      X      DO 75 I=1,M
336.      X      IPEN=2
337.      X      IF(I.EQ.1.OR.IFLAG.EQ.1) IPEN=3,GO TO 65
338.      X      IF(ARRAY4(I).GT.10000)IFLAG=1,GO TO 75
339.      X 65 X2= ARRAY3(I)/SCALE
340.      X      Y2= ARRAY4(I)/SCALE
341.      X      CALL PLOT(X2,Y2,IPEN)
342.      X      IFLAG=0
343.      X 75 CONTINUE
344.      X      CALL PLOT (0.0,0.0,999)
345.      X 80 CONTINUE
346.      X      RETURN
347.      C
348.      END

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